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SUBJECT: Trip Report - Potential On-Orbit
Servicing of TACOMSAT and
Intelsat IV Satellites - Case 105-3

DATE: July 3, 1969

FROM: D. Macchia
M. H. Skeer

MEMORANDUM FOR FILE

The Tactical Communication Satellite (TACOMSAT) and Intelsat IV are the largest communications satellites developed to date. Both satellites are built by Hughes; TACOMSAT for the DOD under direction of SAMSO, and Intelsat IV for the International Telecommunications Consortium under direction of Comsat Corporation. On June 17, 1969, the authors visited Hughes Aircraft Company for discussions pertaining to potential on-orbit servicing of these satellites. Hughes personnel were R. D. Brandes, Manager of Systems Engineering-TACOMSAT; P. Michaelson, Systems Engineer-TACOMSAT, and L. S. Pilcher, Program Manager-Intelsat IV.

The following text is confined to TACOMSAT since little time was available for discussion with Mr. Pilcher and since some general statements regarding satellite serviceability are applicable to both satellites.

TACOMSAT (Figure 1) is an experimental satellite employed to test feasibility of synchronous orbit communications with military field units, aircraft and ships. The satellite was successfully launched on February 9, 1969 by a TIIC booster. The satellite weighs approximately 1,600 lbs and has overall dimensions of 110 inches diameter and 300 inches length. Satellite lifetime is anticipated to be in excess of two years. Program cost was about 30 million and satellite recurring cost is about 15 million.

The satellite is spin-stabilized but contains a despun shelf for mounting earth pointing sensors and antennas (Figure 2). UHF and SHF band communications systems are provided for air-ground and military satellite communications experiments respectively. 1 kw of power is provided by solar cells mounted on the rotating drum. The satellite block diagram shown in Figure 3 delineates subsystems and subsystems interfaces.

Discussions first addressed the general question of despinning a large spin-stabilized satellite such as TACOMSAT prior to servicing. TACOMSAT spin rate is on the order of 54 rpm.

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Spinning could be initially decreased by shutting down the spin motor which maintains the relative spin rate between the despin platform and spinning hub. However, below a threshold spin rate the satellite becomes unstable and tumbling would result. Consequently, for despinning, it would not be sufficient to counter the entire spin solely by RCS. Most likely, physical coupling to a service vehicle would be necessary for complete despin in a stable mode, or the satellite inertia properties would have to be changed.

Precise control of overall system mass properties after servicing operations is not deemed essential. For example, calculations indicated that the satellite could be disassembled and reassembled on the launch pad without introducing cg control problems.

During discussions pertaining to satellite servicing, the communications repeater (transponder) system was selected for detailed examination. The repeater block diagram is shown in Figure 4. The following characteristics of the repeater subsystem relevant to on-orbit servicing were established during the course of the meeting:

- Existing Design Configuration and Accessibility for Servicing - The repeater components are mounted on the lower surface of the despin platform (Figure 5). The configuration is dictated by thermal control requirements, namely distribution of 16 high heat load power amplifiers. At present, the repeater system would not be convenient for servicing since it is totally enclosed within the outer cylinder of solar cells. Access to the satellite interior could be provided by hinged solar panels if servicing were required.

An on-the-pad servicing operation, which in some respects simulated on-orbiting servicing conditions, was undertaken. This involved replacement of an electronic component located on the despun platform similar to the repeater components. To gain access, a solar panel was lifted and a working platform inserted in the open area between the cone and platform sections. Repair time took 2-3 hours after a troubleshooting time of several days.

Inspection of the synchronous orbit TACOMSAT packaging arrangement reveals an extremely low packaging density relative to some satellites launched into low orbit. This is a result of the large available payload volume of the launch vehicle

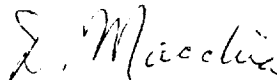
shroud. Consider that TIIIC launch capability to synchronous orbit is of the same order as that of low earth orbit satellite launch vehicles (Thorad-Agena for example). The TIIIC volume envelope is considerably larger, however. Consequently, volume limitations are notably eased and this has been reflected in the design of TACOMSAT. For example, solar panel area for accommodation of the 1 kw power requirements was acquired by a larger outer satellite cylinder, rather than resorting to deployable panel concepts. Thus it appears that servicing would not impose much weight penalty to this type of satellite. In contrast there would be weight penalties associated with servicing densely packaged satellites since increased volume would have to be provided for accessibility.

- Replaceable Components - Almost all components of the repeater system could be replaced individually and be expected to work, though perhaps in a non-optimum fashion. In addition, filters and amplifiers can now be bypassed or operated in various combinations. The repeater subsystems are tested separately, and then "tuned" together by adjusting component characteristics and matching impedances. An exception to the easy replacement of components is the traveling wave tube which is precisely matched to circuit characteristics. In both instances, the best measure of system tuning is power output from the power summer, whereby circuit characteristics are modified until power is maximized. Conceivably, with measurement of maximum satellite transmitted power from the ground, it may be possible to "tune" components in orbit.
- Repeater Updating - Currently the UHF receiver network contains filters of 50 KHZ, 100 KHZ, and 425 KHZ. The human voice by comparison has a bandwidth of 2.4 KHZ. If a 3 KHZ filter could be introduced in lieu of the 50 KHZ filter, a 13 db increase in signal to noise ratio would result. However, to utilize this bandwidth, very accurate reference frequency standards must be achieved.

Because of low ground based power requirements, operation with filters only slightly wider than voice bandwidths are attractive for emergency mode operations. If ground equipment with precise frequency standards becomes available it would be desirable to incorporate a 3 KHZ filter in the repeater subsystem. With on-orbit servicing this could be achieved by replacement of an existing filter.

Possible updating on a larger scale was considered for other subsystems, as for example replacement of the antenna (Figure 6). Principal antenna interfaces with the satellite are mechanical (the electrical interface is simply a cable). Discussion pointed out that on-orbit modifications of this nature should be feasible. This is not to say that such a change is recommended. Experience suggests that for experimental satellites such as TACOMSAT, evolutionary changes and updating are usually accompanied by substantial redesign. The question is not one of feasibility, but rather if modest updatings are justified. Antenna modification may be a more attractive possibility for the Intelsat IV class of satellites with lifetimes of greater than five years.

Both Mr. Brandes and Mr. Pilcher agreed that servicing could be desirable if accomplished cheaply. They questioned the advisability of updating or repair of commercial satellites such as Intelsat IV after a point in time at which satellite value had been substantially depreciated. Furthermore, since many components will have degraded (i.e., bearings, solar cells, slip rings, thermal finishes, valves, etc.), extending nominal design lifetime may require extensive satellite overhaul.



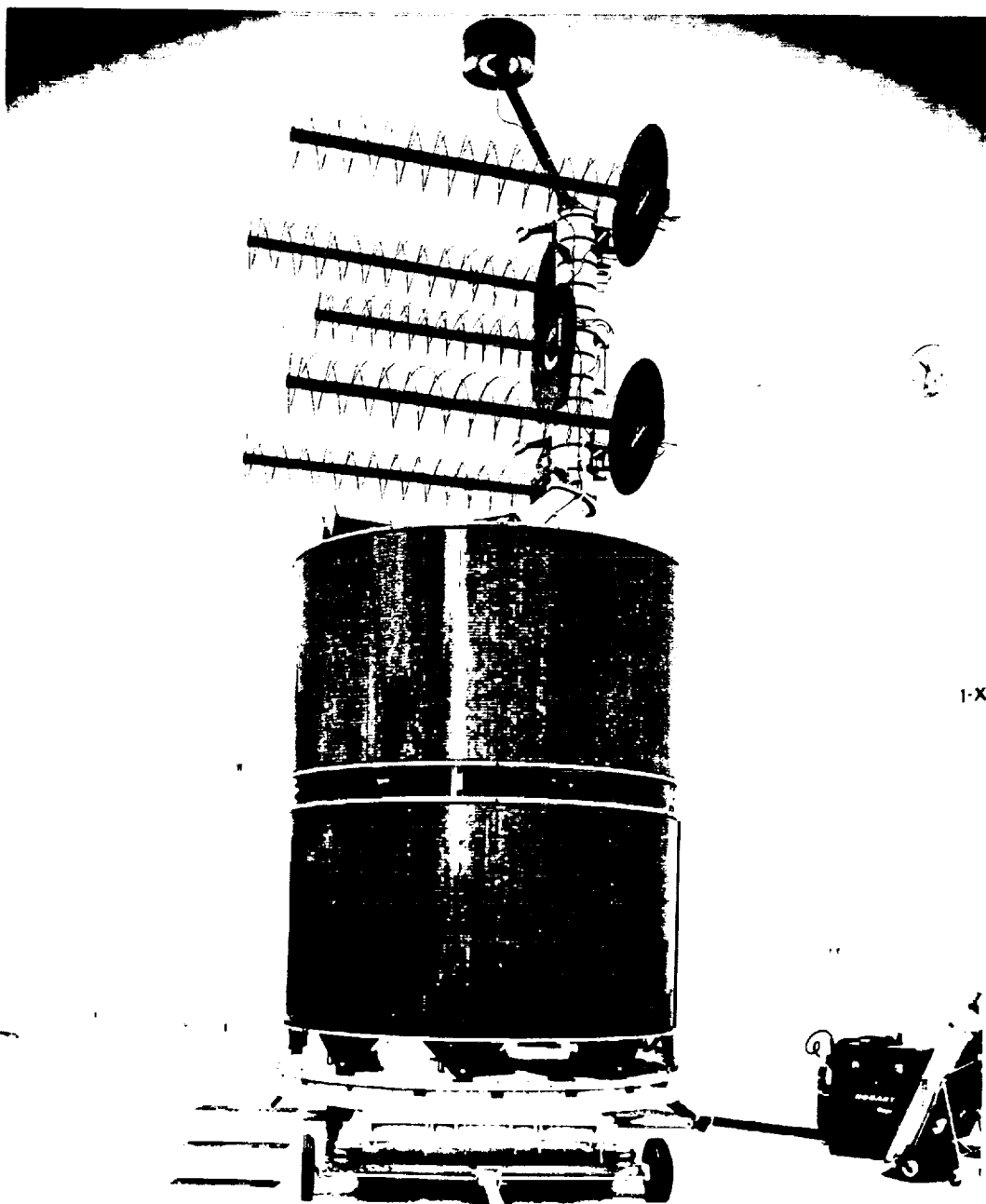
D. Macchia



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Attachments



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FIGURE 1—TACOMSAT OVERALL CONFIGURATION

SATELLITE CONFIGURATION

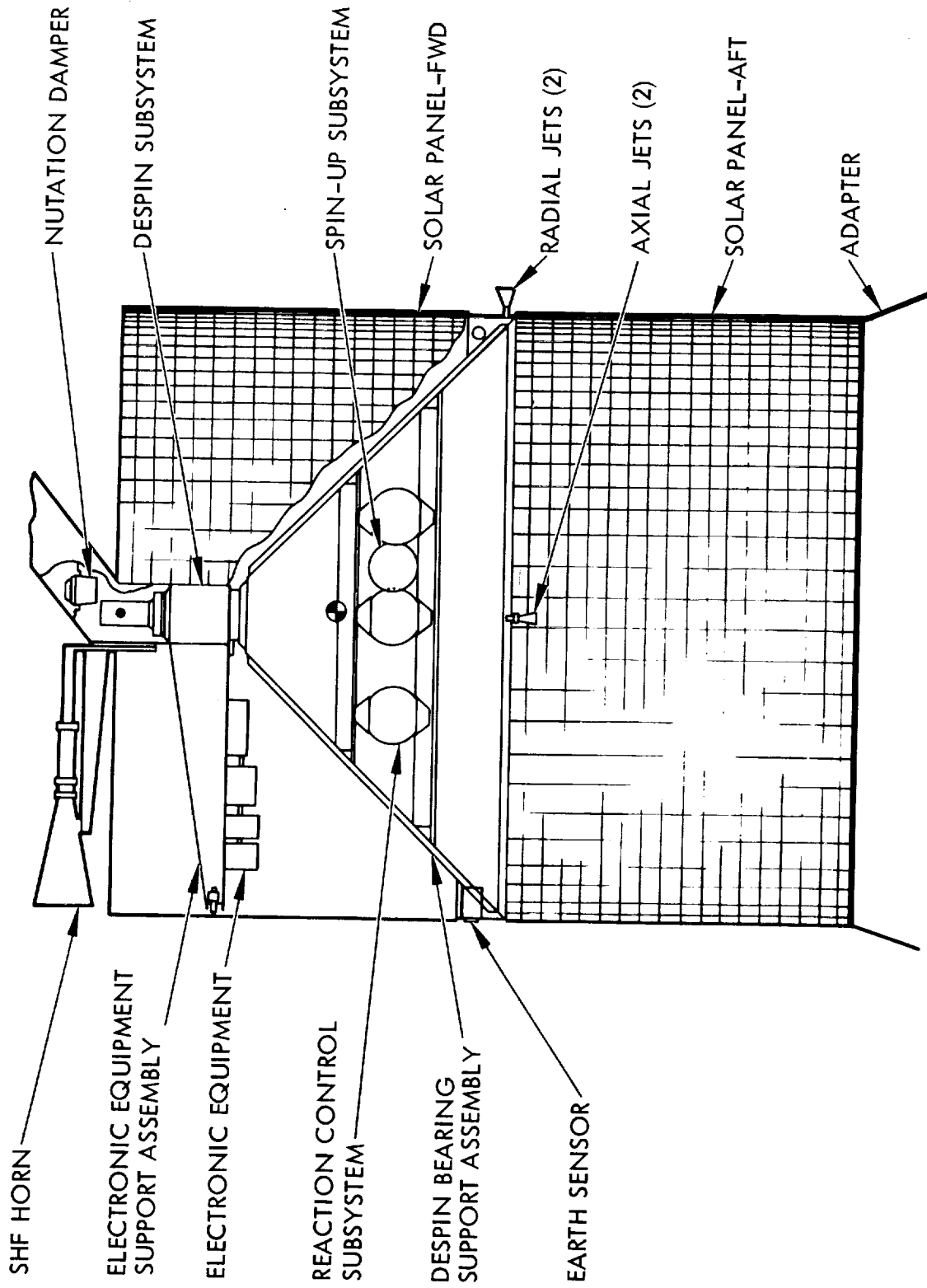


FIGURE 2-TACOMSAT CUTOUT SECTION

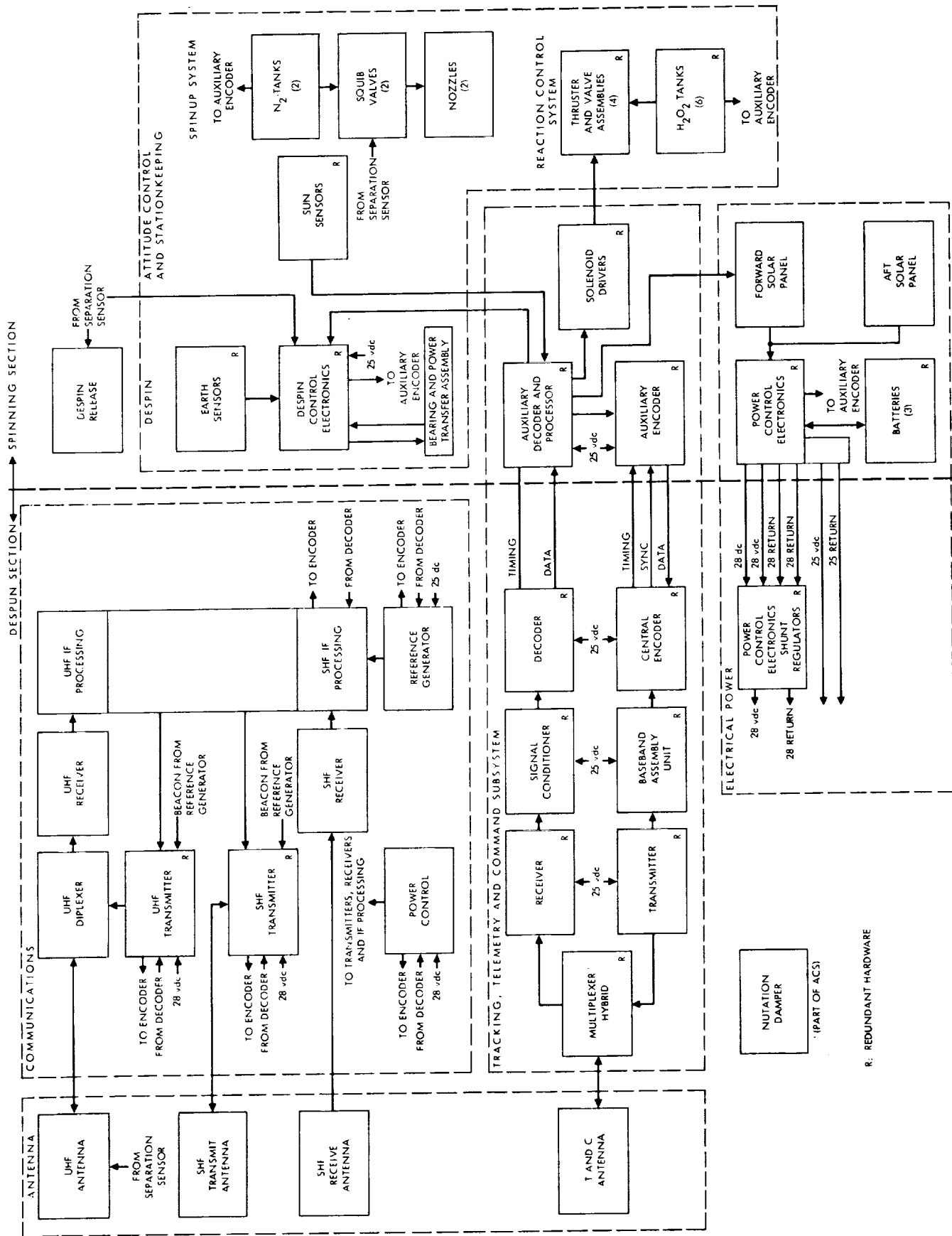


FIGURE 3

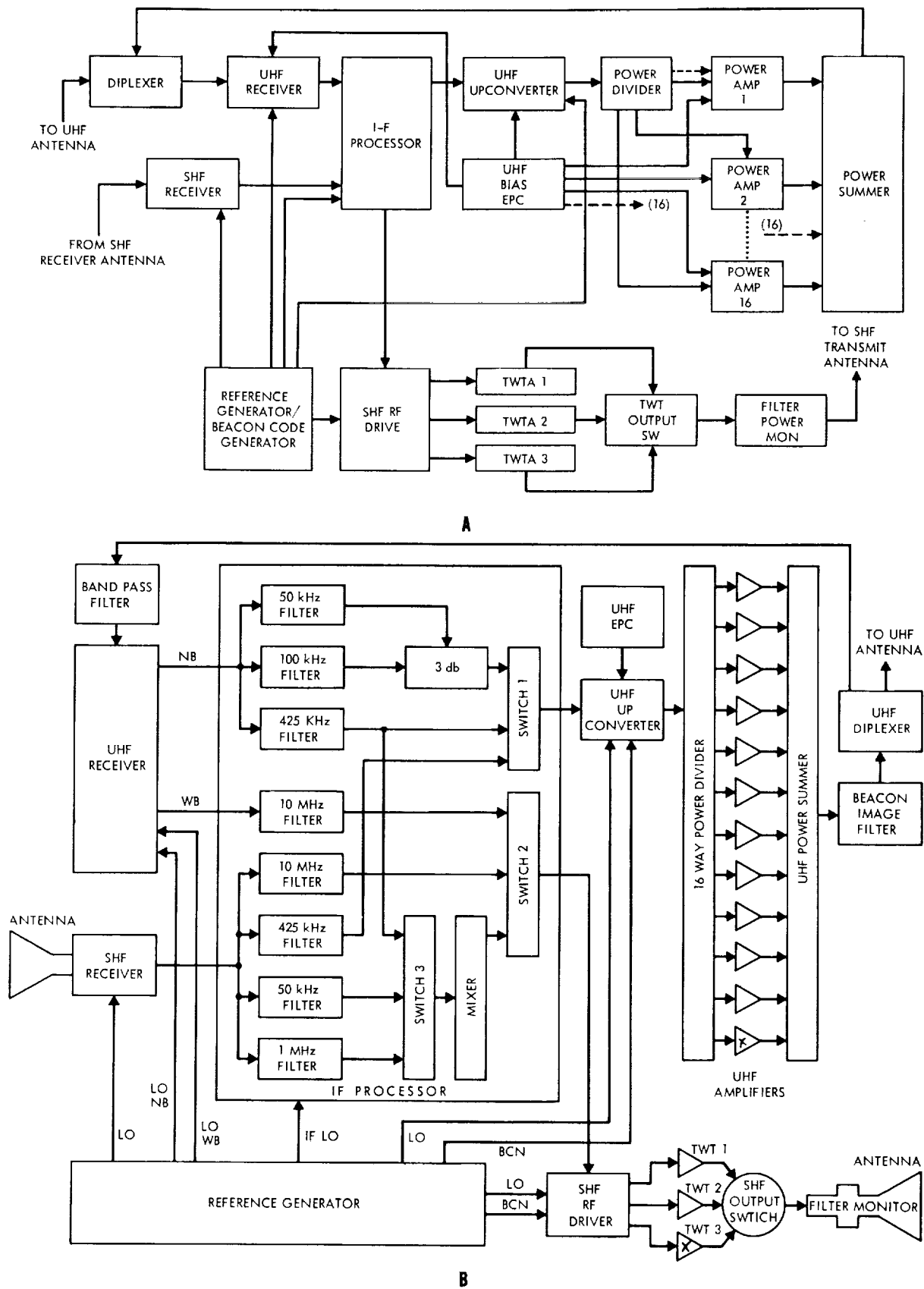


FIGURE 4—COMMUNICATIONS REPEATER

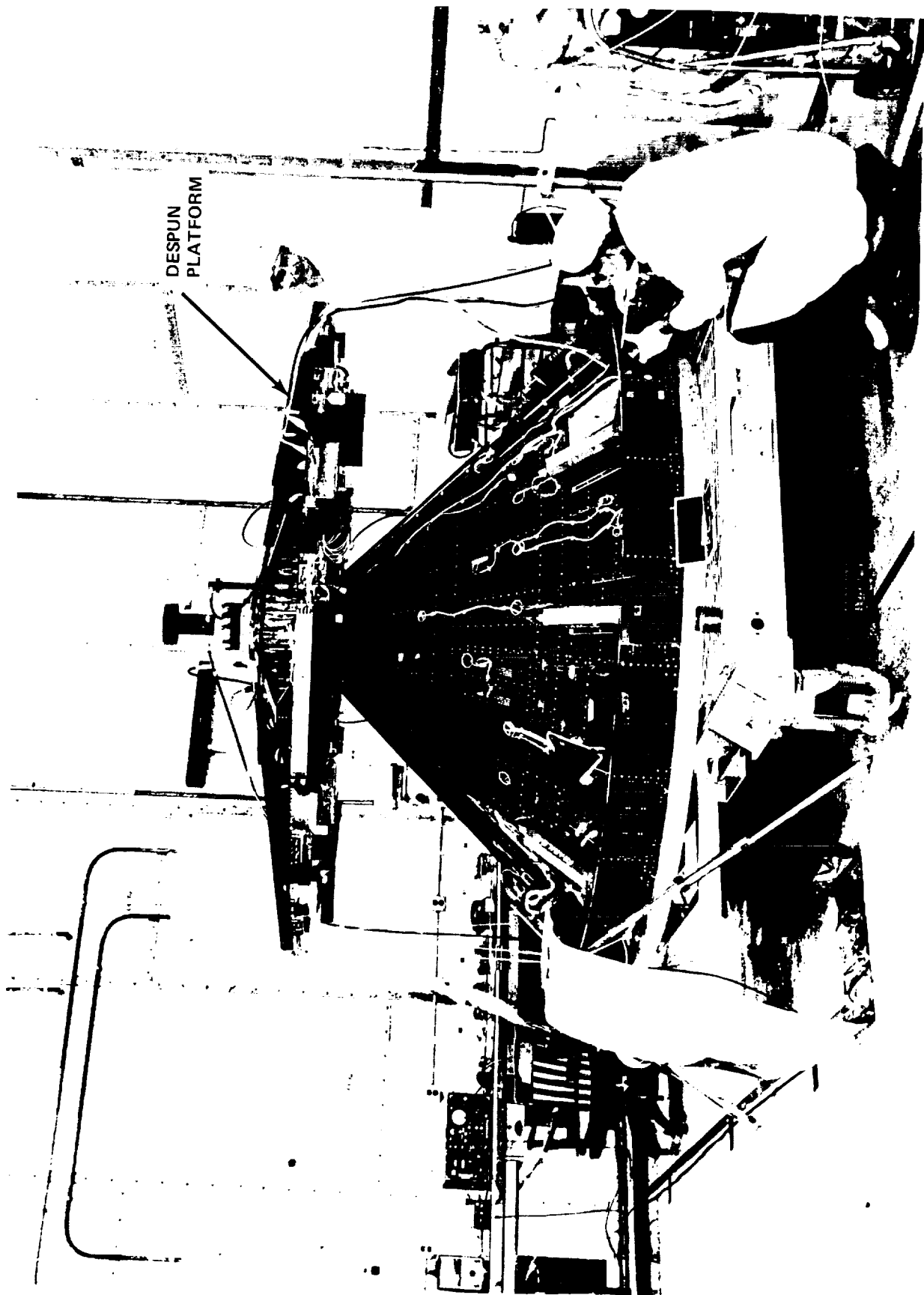


FIGURE 5--TACOMSAT DESPUN PLATFORM

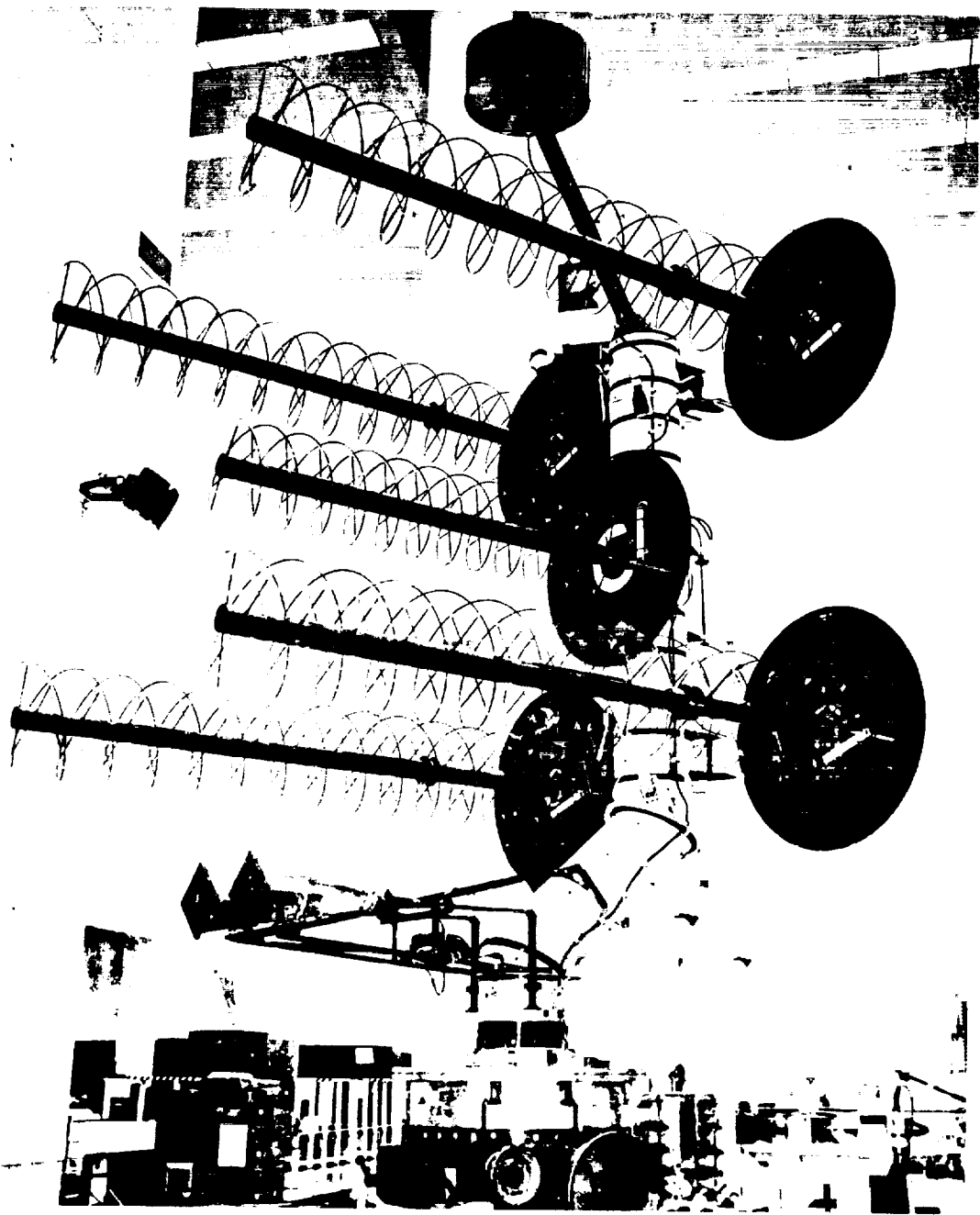


FIGURE 6—ANTENNA-MAST ASSEMBLY

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ABSTRACT

Discussions pertaining to potential on-orbit servicing of TACOMSAT and Intelsat IV satellites were held with Hughes Aircraft personnel. Emphasis was directed to TACOMSAT. It was determined that TACOMSAT has a relatively low packaging density which could enable access to most components.

The repeater subsystem was singled out for detailed discussions. Most components of the repeater could be replaced individually and be expected to work. Optimum performance, however, would require 1) "tuning" components by adjusting component characteristics and matching impedances, or 2) tightening component tolerances.

Regarding satellite updating, bandwidth filter replacement was identified as an example of a worthwhile servicing operation. In contrast, major upratings such as an antenna change, though feasible, are believed to be more appropriately part of a new satellite design.

It was noted that updating or repair of commercial satellites such as Intelsat IV may not be advisable towards the end of the satellite's economic lifetime. Furthermore, due to satellite wearout characteristics, extension of lifetime may require satellite overhaul.

